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FULL PAPER

Evaluation of an internet-based animated preparatory video for children undergoing non-sedated MRI

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Objectives: We evaluate the value of an internet-based educational animated video designed to prepare children for MRI scans, and whether this video reduces scan-related anxiety in children with a neurological disorder, and healthy controls.

Methods: Participants completed a pre- and post-scan questionnaire evaluating participant online viewing behaviour, understanding of the MRI procedure, anxiety regarding the MRI, impact of animation in preparing the child and whether the child's expectation of the MRI scan matched their experience.

Results: 21 children were recruited (12 healthy controls) ranging in age from 6.5 to 11.5 years. The animation was successfully accessed by participants on a range of digital devices and had high levels of approval. Children who viewed the animation had a good understanding of the MRI procedure and low anxiety levels prior to the scan, and reported that their expectations broadly matched the real-life MRI experience. Children reported that the animation positively impacted on their preparation with similar ratings before and after the scan, and the impact on preparation was rated greater by younger children. There were no group differences between healthy children and those with the neurological disorder for ratings of anxiety, impact on preparation and expectation of the experience.

Conclusion: This evaluation demonstrates accessibility, acceptability and relevance of internet-based educational animation for typically developing children, and children with a neurodisability aged 6 to 11 years, with positive impact on preparation for MRI.

Advances in knowledge: The internet-based educational animation provides a widely accessible tool to support preparation of children for non-sedated MRI.

INTRODUCTION

Awake MRI scanning can be difficult for young children due to anxiety caused by the confined space, loud noises, unfamiliar environment and the need to lie still for an extended period of time.[1–3] Anxiety and resultant poor compliance can lead to poor quality images or abandonment of the procedure. General anaesthesia is widely employed in young children having MRI but introduces additional risks and costs, hence alternative strategies should be sought.[4]

Interventions such as play therapy and mock MRI scans increase compliance of children having scans without sedation but are resource and staff intensive.[3,5–8] Internet-based delivery of preparatory materials provides an inexpensive, accessible and time efficient way of enhancing preparation of children for MRI. However, despite the now widespread use of internet-delivered health information,[9] prospective studies evaluating the impact of these materials are generally lacking. We previously developed and evaluated an animated educational video to prepare children for awake MRI and found this animation improved the knowledge and reduced anticipatory anxiety.[10] The participants in this previous report were healthy children who did not undergo MRI, as the focus for this report was on

the evaluation of the attributes of the animation intervention for improving knowledge and reducing anxiety in children in this age range.

Based on this previous work, we now test the novel hypothesis that the animated educational video provides an internet-based tool for MRI preparation that reduces scan-related anxiety in young children undergoing awake MRI. Secondly, we hypothesise that the animated educational video is accessible to a range of children including those with a neurodisability. To explore the hypotheses, we evaluated the animation in two groups of children at opposite ends of a neurodisability spectrum [typically developing children and those with a severe cerebellar ataxia and involuntary movement disorder due to ataxia-telangiectasia (A-T)] undergoing a clinical research MRI scan. Specifically we measured the child and parent rated (1) usage and acceptability of the animation, (2) the child's understanding of the MRI procedure, (3) the child's anxiety regarding MRI scanning, (4) the impact of the animation on preparing the child for MRI scan, (5) whether the child's expectation of the scan matched their experience of the MRI scan and (6) whether there were any differences in the above parameters between the neurological disease and healthy control groups.

METHODS AND MATERIALS

Recruitment

Participants in the Childhood Ataxia Telangiectasia Neuroimaging Assessment Project (CATNAP) aged 6 to 11 years were invited to take part in the evaluation of the animated preparatory video. CATNAP recruited children aged 6 to 18 years with A-T, a progressive neurodegenerative disorder[11] and age-matched healthy controls (HC, children whose physical, cognitive, social and emotional development were deemed typical within the accepted norms for the age of the child). Children with A-T were recruited through the UK National Paediatric A-T clinic at the Nottingham University Hospitals National Health Service Trust. Healthy controls were recruited through posters in the local community. Adult participants were the parents/guardians of participating children. Parents/guardians gave initial verbal consent for participation in the animation evaluation at the time of booking their child's MRI appointment, after which they were sent the internet link to the animation and two information sheets, one that was intended for the parent, and an age appropriate information sheet for their child. Written informed consent for parent and child participation was obtained on the day of the MRI appointment prior to completing the animation evaluation interview and questionnaires. Children under 16 years of age were asked five questions to ensure they were happy to participate in the study. The questions included whether somebody had explained the study to them, if they understood what the study was about, if they had the opportunity to ask questions and whether these questions were answered, and finally if they were happy to take part. If children did not understand the study the researcher would spend time explaining what the study was for, and what it would involve. If the children where physically able to, they were given the opportunity to sign their name on the consent form, otherwise verbal assent was accepted. The children were informed that they had a right to withdraw at any time. The study was approved by the East Midlands (Derby) NHS Research Ethics Committee (14/EM/1175).

The MRI animation

The animation used was an updated version from the Szeszak et al. (2016) study and lasts 3 minutes (m) and 8 seconds (s).[12] The animation is about a young girl called Jess who has an MRI scan. Justification for the characters, dialogue and theme of the animation are described previously.[10]

Procedure

Participants were sent an internet link to the animation prior to the MRI scan appointment so they could watch the animation in advance. Participants received a Research Ethics Committee approved information sheet, which included a brief description of the MRI procedure, and a verbal explanation of the MRI procedure by the researcher on the day of the visit. The animation evaluation questionnaire was completed during the visit for the MRI scan, and comprised three parts (Supplementary Material 1). Parts 1 and 2 were completed before the MRI scan by participating children and parents respectively. Part 3 was completed by children following the MRI brain scan. If required, the researcher would read the questions for parts 1 and 3 to the participating children. Some children were unable to physically complete the questionnaire themselves due to neurological disability therefore the researcher recorded their answers verbatim. Parents self-completed part 2 of the questionnaire.

Questionnaires

In part 1, questions 1–3 asked about participant viewing behaviour. Questions 4–19 were a combination of four-point Likert scales and qualitative responses. Likert scale questions covered three domains: Approval of the animation (five questions), levels of pre-scan anxiety (three questions) and impact of the animation in preparing the child for MRI (three questions). Within each domain responses were summed to create an overall score. Qualitative responses created the fourth domain and were designed to assess the participant's pre-scan understanding of the MRI procedure. Qualitative responses were coded for analysis by the same researcher (HM) for standardisation, with a score of 0 for no knowledge, a score of 1 for some knowledge and a score of 2 for good knowledge.

Part 2 of the questionnaire (completed by parents) assessed technical problems accessing the animation online, improvements that could be made to the animation and the perceived importance of certain aspects of the animation. Questions were made up of Likert and qualitative questions.

Part 3 of the questionnaire assessed four domains, three of which mirrored the pre-scan questionnaire – anxiety, understanding of the MRI procedure and impact of the animation in preparing the child for MRI scan. The fourth domain examined whether the child's expectation of the scan matched their experience. The four-point Likert scale format used in the children's pre-scan animation questionnaire was used in the post-scan questionnaire.

Scan tolerance and image quality

The core MRI scan protocol comprised localisers and five research series (including three-dimensional T_1 weighted volume acquisition) lasting 25m 19s, with three additional series lasting 12m 27s for children tolerating the scan well. Duration of tolerated scan was recorded. Image quality of the T_1 weighted volume acquisition was rated by RD using a five-point scale (Supplementary Table 1).

Analysis

Average ratings in each domain were converted to percentages and interpreted as follows: 0–30% poor, 30–60% moderate, 60–80% good and 80–100% excellent. The relationship of age to impact of the animation was examined by Pearson correlation. One-way ANOVA was used to explore group differences across total scores from each domain. Results of descriptive statistics are reported as mean ± SD unless stated otherwise. Qualitative data can be found in the Supplementary Material 1. Statistical analyses were performed with SPSS v. 21 (Armonk, NY: IBM Corp).

RESULTS

Participants were 12 males and 9 females aged 6.5 to 11.5 years (9.23 ± 1.68). There were nine children with A-T and 12 HC with no group differences in sex [$F(1,20) = 0.543$, $p = 0.470$] or age [$F(1,20) = 0.202$, $p = 0.658$]. Based on parental reports nine children had previous MRI scans (eight from the A-T group and one from the HC group). Three children had previous scans under general anaesthetic, two children had previous scans while awake, one child had scans both awake and under general anaesthetic and three parents did not answer this question.

Viewing behaviour and approval

Of the 21 children, 9 (43%) watched the animation only once and 12 (57%) children watched the animation two to five times. 18 children (86%) watched the animation with family and 3 children (14%) watched the animation alone. The device on which the child watched the animation was spilt between laptop computer (6), desktop computer (6), tablet/iPad (4) and mobile phone (5). When asked how much the child liked the animation the total mean score was 16.9 ± 2.3 out of a maximum of 20 (84.5%). Child approval and parent importance ratings for animation components can be seen in Figure 1a,b. Free text comments suggested improvements that could be made to make the animation more appealing. For example, an 11.5-year-old female from the HC group stated, "I would have liked it more if there were some more noises of what the scanner sounded like and more about the types of gear/equipment you have to wear." A 9.5-year-old female from the A-T group commented that she would have liked "more realistic noises, to show a real scanner, and reassure that it won't hurt them." To see all of the free text comments collected for this study please refer to Table 1a–g .

Knowledge, anxiety, preparation and expectations regarding the MRI procedure

As can be seen in Figure 2, the children had a good pre-scan understanding of the MRI procedure with a whole group mean of 7.7 ± 1.6 points out of 10 (77%). Pre-scan anxiety for the whole group was low with a mean score of 5.5 ± 1.3 out of 12 (45.8%) (lower scores indicate lower levels of anxiety). Post-scan anxiety was 47.5% or a mean of 11.4 ± 3.8 out of 24. The impact the animation had on preparing the children for the MRI before their scan was rated good with a whole group mean of 8.6 ± 1.8 out of 12 (70.8%). Impact of the animation post-scan was rated good with a mean of 13.8 ± 3.4 out of 20 (69%). The good level of impact the animation had on preparing the children for their scan was reflected in some of the comments from their parents, including "This was undoubtedly essential for us to make sure the children understood what to expect and to provide reassurance – it helps remove the anxiety" (parent of a 7.7-year-old child in the A-T group) and "An accessible way to present what's going to happen" (parent of a 7.1-year-old child in the HC group).

There was a significant negative relationship between age and impact on preparation rated post-scan ($r = -0.669$, $p = 0.001$), which approached significant pre-scan ($r = -0.427$, $p = 0.053$) indicating the animation had a larger impact on younger children. This age-related impact was reflected in the free text comments. For example, a 10.6-year-old male from the HC group commented, "It was aimed at younger children". These comments indicate the older children would have liked a more mature version of the animation. The post-MRI rating of whether pre-scan expectations of the MRI experience were met was good (72.5%, 8.7 out of 12).

Group differences in responses

Results of the one-way ANOVA testing for group differences in pre- and post-scan ratings of understanding of the MRI

Figure 1. Bar charts to show (a) mean child-rated approval and (b) mean parent-rated importance of different components of the animation.

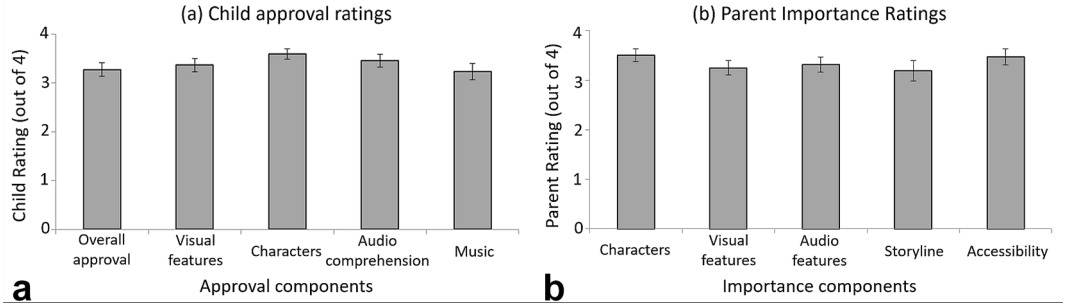

Table 1. (a) Free text comments of children from both groups to Question 51. (b) Free text comments of parents from both groups to Question 29. (c) Free text comments of parents from both groups to Question 30. (d) Free text comments of parents from both groups to Question 31. (e) Free text comments of parents from both groups to Question 32. (f) Free text comments of parents from both groups to Question 33. (g) Free text comments of parents from both groups to Question 34

(a) Question:	**Child**	**Now that you have had the scan is there anything that you think should be different about the cartoon?**
Participant	Group	Responses
2	A-T	Louder noises
3	A-T	More realistic noises, show a real scanner, reassure it won't hurt them
7	A-T	More explanation of the noises and advice re bringing CD or DVD
8	A-T	More noises, bigger scanner - too small in cartoon
9	A-T	More noises, there were no boxes to put metal in
11	HC	Nothing
12	HC	I think the cartoon didn't have anything missing
13	HC	I would have liked it more if there were some more noises of what the scanner sounded like. More about types of gear/equipment you have to wear
14	HC	I think they should have showed more sounds and about watching a movie
15	HC	Amount of time each picture took. Showing a real MRI scanner
16	HC	More loud noises - different head story
17	HC	It was aimed at younger children
18	HC	Say you could watch a DVD I thought it was smaller it was longer than I thought
21	HC	Not really
22	HC	Elephants and tigers, lions, wolves, animal characters
(b) Question:	**Parent**	**Overall, do you think that the animated film helped to prepare your child for their scan?**
Participant	Group	Responses
3	A-T	First of all she was scared but watches again she felt good
5	A-T	We have had previous scans it would have been helpful before the first one
6	A-T	Good to have a character to relate to
8	A-T	This was undoubtedly essential for us to make sure the children understood what to expect and to provide reassurance. Helps remove the anxiety
10	A-T	Helped make everything more clear
13	HC	Noise, showing it. Visual of MRI and room
14	HC	Showing noise, showing MRI room
15	HC	Accessible way to present what's going to happen
21	HC	Not really
22	HC	Elephants and tigers, lions, wolves, animal characters
(c) Question:	**Parent**	**Do you think the animated film help your child's attention better than a booklet would have done?**
Participant	Group	Responses
10	A-T	Definitely 100%
14	HC	Daughter watched it on her phone
21	HC	Children today are far more likely to pay attention to a cartoon
(d) Question:	**Parent**	**Do you think that similar animated films would help to prepare children for other hospital procedures?**
Participant	Group	Responses

(Continued)

Table 1. (Continued)

(d) Question:	Parent	Do you think that similar animated films would help to prepare children for other hospital procedures?
5	A-T	Procedures often have very complex names and it's not clear what they involve
6	A-T	Especially important for children not having had an MRI previously
8	A-T	I think this should become standard procedure, the idea of the animation is fantastic, children need to understand what procedures will be, how they will be done, noises to expect etc. doing this visually is much better for a child
(e) Question:	**Parent**	**Is there anything you thought was particularly bad about the film?**
Participant	Group	Responses
1	A-T	Just that it narrates the doctor will find out why you are ill. Maybe something else would be appropriate
3	A-T	No
5	A-T	No
6	A-T	No
8	A-T	No
10	A-T	No
11	HC	No
13	HC	Cartoons maybe a bit babyish for older kids
14	HC	No
16	HC	The music
18	HC	No
19	HC	Just being able to access it straight from email would be better
21	HC	No
(f) Question:	**Parent**	**Is there anything you thought was particularly good about the film?**
Participant	Group	Responses
1	A-T	Detail was excellent
2	A-T	Short but thorough
3	A-T	Very encouraging as children can be scared otherwise
4	A-T	Very good for younger children
5	A-T	Nice and upbeat
6	A-T	The information about metal and the advice about loud noises. Also imagining what to do in the scanner was important as duration of scan is long
8	A-T	All good
10	A-T	It was clear, simple and easy to understand. Kept his attention as it wasn't too long
11	HC	Friendly characters but an accurate presentation of the equipment
13	HC	Showing not just telling what it was
14	HC	Nice length
15	HC	Sets expectations on noise and other facts that might be frightening
16	HC	Short enough to retain interest but gave all relevant facts
18	HC	Child talking about using her imagination for the noises
21	HC	Very simple and easy to understand
(g) Question:	**Parent**	**How could the film be improved?**
Participant	Group	Responses
5	A-T	Perhaps include a few more sound samples to give a better idea of what to expect

(Continued)

Table 1. (Continued)

(g) Question:	Parent	How could the film be improved?
6	A-T	A male character equivalent for boys
8	A-T	Perhaps include a few more of the noises involved and explain there is no pain
10	A-T	It seems good and clear
13	HC	Not so babyish. Less rockets more telling it as it is though my younger son liked the rocket
14	HC	Good for this age group
18	HC	Tell children can take a DVD with them

A-T, ataxia-telangiectasia; HC, healthy controls.

procedure, anxiety, impact on preparation and scan expectation are shown in Table 2. No significant differences between groups was found except for pre-scan understanding of the MRI procedure.

Parent/guardian responses

Results from the parent/guardian questionnaire showed 100% of parents agreeing that the animated film helped prepare their child for the MRI scan, that the film held the child's attention better than a booklet would, and future animated films would help prepare children for other hospital procedures. Examples of comments from the parents included that the animation was "more memorable than a booklet", "Children today are far more likely to pay attention to a cartoon", and "I think this should become standard procedure, the idea of the animation is fantastic, children need to understand what procedures will be, how they will be done, noises to expect etc. doing this visually is much better for a child". For more supporting free text comments see Table 1a–g.

Scan tolerance and image quality

19 of 21 children completed the core MRI research protocol (90%). Medium scan duration was 37m 46s (range 19m 43s to 37m 46s (Table 2). 18 of 21 children (86%) had scan quality rated as "minor" or "no" movement artefact visible. Scans from three children in the A-T group showed movement artefact, for two (aged 10.2 and 8 years) rated as "moderate" for one (aged 9.5 years) rated as "severe" (Supplementary Table 1).

DISCUSSION

Digital media are widely used to deliver health-related information.[9] A number of internet-based animations and "apps" are available to help prepare children for medical procedures. Ease of access combined with high levels of engagement with digital media by children suggests intuitively that these materials will be successful in informing children about the procedure and thus reducing anxiety and improving compliance. However, there is a paucity of properly conducted evaluations of such digital materials. Evaluation of publically available digital materials is important to confirm efficacy of the material, for justifying resource allocation for development and maintenance.

Our previous evaluation of this animation in healthy children not having MRI showed that the animation retained attention, improved knowledge of MRI procedure and reduced anticipated anxiety of MRI.[10] The current work aimed to extend these previous findings by recruiting both typically developing children and children with a neurodisability, with both groups

Figure 2. Bar chart to show comparison of child-rated knowledge, anxiety and preparation pre- and post-scan.

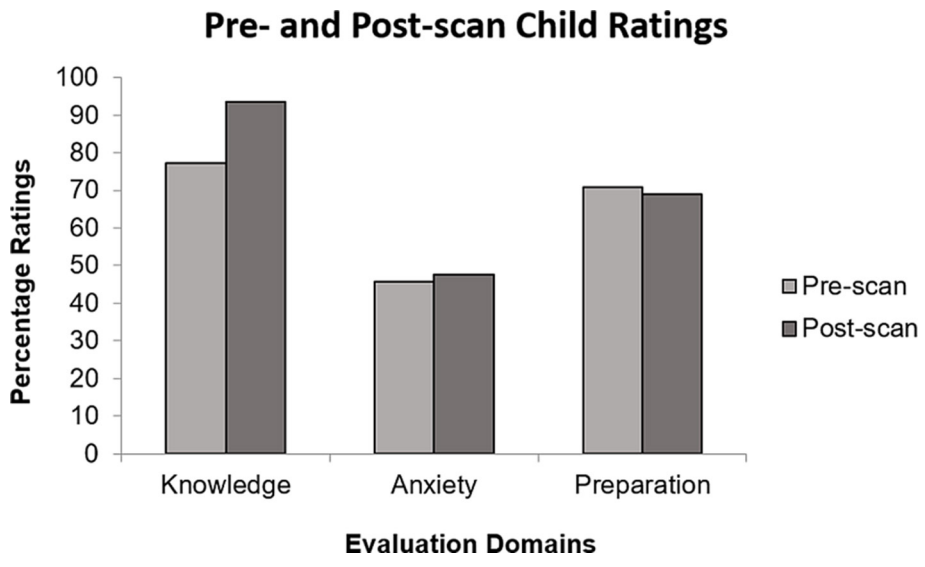

Table 2. Descriptive statistics and one-way ANOVA results for the comparison of variables between groups

		M(SD)		*F*	*p*
		A-T	HC		
Before MRI scan	Understanding of the MRI procedure (out of 10)	6.9 (1.3)	8.3 (1.6)	4.91	0.04
	Anxiety regarding the MRI scan (out of 12)	5.9 (0.6)	5.2 (1.6)	1.67	0.21
	Impact on preparation for the MRI scan (out of 12)	8.8 (2.0)	8.4 (1.7)	0.20	0.66
After MRI scan	Understanding of the MRI procedure (out of 8)	7.6 (0.9)	7.4 (0.8)	0.14	0.71
	Anxiety regarding the MRI scan (out of 24)	12.9 (4.7)	10.3 (2.7)	2.65	0.12
	Impact on preparation for the MRI scan (out of 20)	14.4 (3.9)	13.4 (3.1)	0.37	0.55
	Expectation of the MRI experience met (out of 12)	8.3 (2.2)	8.9 (1.6)	0.48	0.47

A-T, ataxia-telangiectasia; HC, healthy controls; M(SD), Mean (standard deviation).

undergoing an MRI scan. It was hypothesised that the animated educational video would provide a tool for MRI preparation that reduced scan-related anxiety in young children undergoing MRI. Our results showed that moderate levels of anxiety regarding MRI scanning were reported before the scan, and hence the animation does not fully reduce anxiety. Similar levels of anxiety regarding MRI were reported after the scan. Free text comments show that tunnel size and scanner vibrations contribute to residual feelings of anxiety. Nine children across both groups commented they wanted more realistic and louder noises in the animation and six children wanted a better indication of scanner size.

Our second hypothesis was that the animated educational video would be accessible to a range of children including those with a neurodisability. The results supported this hypothesis with no significant differences between HC and A-T groups for pre- and post-scan ratings of understanding of the MRI procedure, anxiety, impact on preparation and scan expectation except for pre-scan understanding of the MRI procedure. The animation was considered valuable across groups for both children and parents demonstrated by high approval ratings. Furthermore, children who view the internet-based animation before MR scanning had a good understanding of the MRI procedure with their expectations broadly matching the real-life MRI experience. Children across both groups reported that the animation positively impacted on their preparation, with similar ratings both before and after the scan. The lack of change in ratings is important; a significant drop would have indicated that the children felt the animation failed to prepare them for the real-life MRI. Correlation analysis revealed a strong negative relationship between age and impact of the animation on preparation indicating higher impact ratings for younger children. Two older children and two of the parents commented that they would like a version of the animation for older children. The utilisation of a more mature educational video to prepare older children for MRI has been found efficacious in a study by Hogan et al.[13] The educational video used in their study did not find a significant improvement in relaxation for younger children under the age of 13. This may suggest that the type of animation used in our study should be utilised for younger children, with older children benefitting from the video format that Hogan et al evaluated.

Limitations

Our results are limited by small sample size and only included a single highly-selected disease group. Three participants had had previous awake MRI which could impact on measures of procedural knowledge and anxiety. The lack of a comparator group of children who were not shown the animation means that we cannot dissociate the effects of animation from the effects of standard preparatory strategies such as printed material and verbal explanation, although our previous evaluation of the animation in MRI-naïve children showed that the animation alone improved knowledge and reduced perceived anxiety. Another limitation of this study is that the questionnaires that were used for this study were all paper based, whereby the child was required to use a pencil to circle the number that represented how they felt to given statements. This method limited some of the children's ability to be able to physically respond, instead having to verbally communicating their answer. Future research may address this limitation by using computer tablet-based questionnaires where the child can select their answer by pressing on the icon that represents how they feel to each statement. Finally, we used an in-house developed questionnaire that included questions relating to anxiety, but could have used, modified, or selected items from a structured validated paediatric anxiety questionnaire, of which a number are available (for example, the State Trait Anxiety Inventory for Children[14] or the Penn State Worry Questionnaire for Children).[15] Furthermore, future research should also evaluate the impact of parental anxiety on child compliance with MRI. Any items used from a validated questionnaire may also be adapted to a computer tablet format using picture response options so that the format is more user-friendly in this population.

CONCLUSION

This evaluation demonstrates accessibility, acceptability and relevance of internet-based educational animation for typically developing children, and children with a neurodisability aged 6 to 11 years, with positive impact on preparation for MRI. The animation provides a widely accessible tool to support preparation of children for non-sedated MRI.

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